Revista Brasileira de Gestão e Desenvolvimento Regional
G&DR. V. 16, N. 2, P. 524-536, mai-ago/2020. Taubaté, SP, Brasil.
ISSN: 1809-239X

Received: 03/30/2020
Accepted: 06/15/2020

NOISE MANAGEMENT IN AN AERONAUTICAL MAINTENANCE CENTER

GESTÃO DO RUÍDO EM UM CENTRO DE MANUTENÇÃO AERONÁUTICO

Rafael Felipe Guatura da Silva[1]
Luiz Antonio Perrone Ferreira de Brito [2]
José Luís Gomes da Silva[3]

Abstract

Noise can damage human health, such as hearing loss, stress, irritability, sleep disorders and fatigue. In addition, it can be a facilitator for the occurrence of errors in the work environment and reduce the professional's performance. The aim of this study was to assess the impact of noise on the physical and mental performance of professionals in an aeronautical maintenance facility. Descriptive, quantitative and exploratory study used as method. Applied on a sample of pilots, aircraft mechanics, inspectors and managers at an aeronautical maintenance center a self-reported questionnaire, seeking to identify health problems and symptoms related to excessive noise in the workplace. The results obtained identify professionals who report feeling frequently irritated, experiencing headaches, difficulties with concentration, hearing tinnitus after working hours and hearing problems. The frequency of hearing problems increased according to the age of the professionals and the time they work with aeronautical activity. In view of this, the results refer to the noise pressure levels of this maintenance center that affect both the health of human resources, as well as the performance of their professional activities.

Keywords: Management. Regional Development. Aeronautical Noise. Professional Performance.

Resumo

O ruído pode trazer sérios prejuízos à saúde humana, como a perda auditiva, estresse, irritabilidade, distúrbios do sono e fadiga. Além disso, pode ser um facilitador de ocorrência de acidentes, erros no ambiente de trabalho e reduzir o rendimento do profissional em suas atividades. Este artigo tem como objetivo avaliar o impacto do ruído no desempenho físico e mental dos profissionais de um centro de manutenção aeronáutica. O método utilizado foi de um estudo descritivo, quantitativo e exploratório. Aplicou-se um questionário de autorrelato em uma amostra de pilotos, mecânicos de aeronaves, inspetores e gerentes de um centro de manutenção aeronáutico buscando identificar problemas de saúde e sintomas que possam ter relação com o excesso de ruído no ambiente de trabalho. Os resultados obtidos identificaram profissionais que relataram sentir-se irritados com frequência, sentir dores de cabeça, dificuldades de concentração, ouvir zumbido após o horário de trabalho e apresentar problemas auditivos. Os problemas auditivos foram mais frequentes de acordo

[1] Master in Management and Regional Development from the University of Taubaté, Taubaté - SP, Brazil. Email: rafaelguatura@hotmail.com
[2] PhD in Civil Engineering (UNICAMP). Professor at the University of Taubaté, Taubaté - SP, Brazil. Email: lapfbrito@gmail.com
[3] PhD in Science (ITA). Professor at the University of Taubaté, Taubaté - SP, Brazil. Email: gomesdasilvaster@gmail.com

com o aumento da idade dos profissionais e o tempo que o mesmo trabalha com atividade aeronáutica. Em vista disso, os resultados indicam que o nível de ruído no centro de manutenção afeta tanto a saúde quanto o rendimento e desempenho das atividades dos profissionais.

Palavras Chave: Gestão. Desenvolvimento Regional. Ruído Aeronáutico. Desempenho Profissional.

Introduction

Exposure to acoustic noise has been frequent in human life, everywhere and at all times. According to Bistafa (2018) exposure to excessive noise deteriorates health and generates hearing loss, sleep loss, tension, interference with oral communication, and digestive problems, among others. Teles and Medeiros (2007) divide the effects of high sound exposure into auditory and extra auditory. Extra hearing loss consists of circulatory, digestive, endocrine, immune, brain and nervous system disorders, and also vestibular and muscular disorders. The hearing effect generally evolves into partial or total deafness (TELES; MEDEIROS, 2007). Besides the physiological damage there is also the psychological effect on human health. At first, there are sleep disturbances, impairment of daily activities, difficulty in communication, lack of concentration, tinnitus, annoyance, stress and fatigue. Afterwards, a harmful hormonal production can be triggered and intermediate effects can arise, such as increased blood pressure. Exposure to noise over a prolonged period may also increase the risk of psychiatric and cardiovascular disease (PÁSCOA, 2015; BISTAFA, 2018).

The extra-auditory effects of exposure to excessive noise, or noise pollution, are little known by a large part of the population. Due to their subjective character, physiological and emotional reactions are mostly not attributed to noise pollution (VIANNA, 2014).

Noise pollution is considered a public health problem, and among the pollution that most affects the world's population, it ranks second in damage to human health, surpassed only by air pollution (CELESTINO, 2017; PALMA, 2018). Several studies can be found in the literature on the effects of excessive noise in people such as Belojevic *et al*. (2008) who reported increased male hypertension; Pirrera, Valck and Cluydts (2014) who related noise to sleep disorders in Belgium; and Weber, Haase, Franck (2014) who found a strong correlation between noise-induced stress and its influence on the human immune system. According to Brito (2018), even medium-sized cities have an excess of noise capable of generating damage to the health of the population, both in the environment and the workplace.

A population that has health compromised directly affects local and regional development because it reduces the performance of productive activities (SILVA; BRITO; VIEIRA, 2019). As already seen, excessive noise generates a series of harmful effects on human health, such as fatigue that favors the occurrence of work accidents (ATALAY; BABAKURBAN; AYDIN, 2015). Fatigue and work accidents, in turn, further burden the already deteriorated public health system in Brazil, generating a vicious circle, and increasingly damaging economic activities and quality of life in general (BRITO, 2018).

Estimated that in Western Europe, with a population of approximately 340 million people, one million healthy people each year have their health compromised by some noise pollution disorder (WHO, 2009).

Sonego, Santos Filha, Moraes (2015) demonstrated that when people are aware of the ills caused by noise, they tend to seek prevention and mitigation measures. Silva, Silva and Brito (2019) carried out an analysis of the noise landscape around an aerodrome, and it was shown that aeronautical noise brings discomfort to the neighboring population. However, it was also noticed that as people's residence time in that area increases, they tend to get used to noise, which leads them to believe that there is no health damage and that mitigation measures are not necessary. These results corroborate the findings of Bistafa (2018) and Brito, Barbosa (2014).

Providing people with information on the risks related to exposure to noise is essential if damage is not to be neglected and health is to be preserved (VIANNA, 2014).

The aim of this study was to assess the impact of noise on the physical and mental performance of professionals in an aeronautical maintenance facility.

Review of Literature

Sound can be characterized as an acoustic phenomenon, originated by the sound propagation produced by a source, through air or a liquid or solid environment. Noise is the result of sound with specific characteristics of intensity and continuity, regardless of its medium of propagation (BARBOSA, 2015). The means of propagation are responsible for transmitting vibrations and therefore produce a variation in pressure and generate the sound waves detectable to the human ear. Thus, sound propagated through the air is an auditory sensation resulting from variations in the atmospheric pressure (BARBOSA, 2015).

The elimination of noise sources would be the best option not to cause harm to human health; however, in most cases this is not possible (SKALEE; BRANDÃO; TEIXEIRA, 2014). In such situations, receivers should be protected from excessive noise with personal protection or awareness (SILVA, 2020).

The normal human voice tone varies between 50 and 55 dB at one meter of distance. For speech intelligibility and understanding, the tone of voice must be 15 dB above the background noise. One of the effects of the high level of noise in the working environment is the difficulty and failures of communication (BISTAFA, 2018). This condition negatively impacts the work environment because it interferes with communication, task transmissions and team activities. This increases the chances of errors in production and leadership processes (VIANA; TEIXEIRA 2017).

This effect becomes worse over the years and results in hearing loss and/or disability. Another occurrence is tinnitus, which also reduces the quality of life of human beings, their professional performance and ability to concentrate and communicate due to fatigue (VIANA; TEIXEIRA, 2017).

Boger and Barreto (2015), in a study seeking to assess the association of hearing loss and tinnitus in workers exposed to noise levels above 85 dB in their work environment, showed that 49% of the sample had alterations in their hearing tests and 45.8% complained of having tinnitus problems. The study by Atalay, Babakurban and Aydin (2015) tried to identify hearing loss in 234 professional's aged 25 to 54 through annual examinations between the years 2005 to 2014. Age, period of exposure to noise and time of activity (years) were analyzed. The results were significant showing the relationship between hearing loss, age and time of activity at work.

Babisch and Kamp (2009) showed in their study that people exposed to a mean sound pressure level (L_{Aeq}) of 55 to 65 dB are more likely to develop hypertension problems and for those exposed to L_{Aeq} of 60 to 65 dB, the chances of developing these problems rise 1.2 times.

Excessive noise increases the probability of fatigue in humans due to nervousness, stress, altered cardiovascular and hormonal activities (LEE *et al*., 2019; GOUVEIA *et al*., 2015).

Kjellberg, Muhr and Skoldstrom (1998) researched the relationship between fatigue and professional performance in noisy environments. The researchers identified a tendency to headaches, physical and mental fatigue and a significant reduction in performance in their work activities.

Fatigue in the working environment can be considered a risk factor by increasing the incidence of errors. It influences the occurrence of accidents by reducing information processing skills in dangerous situations, and by the difficulty of response in challenging situations (GOUVEIA *et al*., 2015). Frone and Blais (2019) point out that fatigue can be generated from situations of physical and mental fatigue in addition to being influenced by emotional situations.

Kanashiro (2013) treats human fatigue in aviation as a complex problem, with a negative impact on the lives of professionals, due to the damage it can cause to their health and the effects reflected on work processes. The author classifies the situations that generate fatigue in the aeronautical environment into operational and individual. In the case of operational situations, it includes elements such as environment, ergonomics and noise. The individual situations include physiological factors (health, physical conditioning, sleep and nutrition), psychological factors (motivation, social problems) and professional factors.

Excessive noise in the working environment can not only damage the health of the worker, but can also be the source of accidents. Inattention, irritability and fatigue, resulting from high exposure to noise, may lead to the individual not being able to perform their activities with the required skill, increasing the risks of accidents (DIAS; CORDEIRO; GONÇALVES, 2006).

The working conditions of aviation professionals face situations that could lead to problems, from the simplest to the most complex. Inadequate working conditions can create discomfort, irritability and stress for professionals, and can be a generator of errors, leading to situations that

compromise both the safety of the worker and the efficiency of the activities performed by him, and consequently also compromises the safety of the aircraft and its passengers (KUBE, 2010).

The high noise level, besides harming the life, health and wellbeing of the professionals, can also degrade the ability to develop their working activities safely, efficiently and effectively, favoring the reduction of performance and the occurrence of errors (CARTHEY, 2019). Aeronautical maintenance aims to provide the aircraft service with quality and safety. In this way, any factor in the work environment that may generate a failure in the maintenance process must mitigated to ensure safety in relation to future accidents (CAMPOS, 2015).

Method

This research is a descriptive, quantitative and exploratory study, carried out in an aeronautical maintenance center and was elaborated following the ethical precepts according to the guidelines established by Resolution 466/2012, of the National Health Council. The procedure was approved by the Research Ethics Committee, by the Consolidated Decision No. 3,642,031 on October 11, 2019.

The study area consists of an aircraft maintenance facility that has six hangars. On the external side of the hangars, the aircraft are activated for maintenance, testing and flights. The study population is composed of 450 professionals who directly perform maintenance activities, inspectors, managers and pilots.

A sample was used for convenience of 207 professionals, obtaining a sample power of 95% and a confidence level of 95% (α= 5%) calculated from Equation 1 (VIEIRA, 2011).

$$n = \frac{N.\delta^2.\left(\frac{z\alpha}{2}\right)^2}{(N-1).(E)^2+\delta^2.\left(\frac{Z\alpha}{2}\right)^2} \quad (1)$$

Where:

n = sample; N = population size; Zα= critical value for the desired degree of confidence; = population standard deviation of the variable; E = standard error; p = proportion of favorable results of the variable in the population; q = proportion of unfavorable results in the population (VIEIRA, 2011).

The application of the questionnaire started on October 22 and ended on November 3, 2019. The surveyor personally delivered the printed questionnaire to 230 professionals and had a return of 208. The Cronbach alpha statistical test was used to check the reliability of the sample.

The measurable variables sought to identify the main activity of the professionals, their knowledge regarding the sound quality of the workplace, the damage they may eventually have on their health, and the report of diseases linked to high sound exposure.

By using the questionnaire it was possible to identify the profile of the professionals interviewed, to identify whether the professionals are aware of the risks that noise exposure may bring to their health and to identify health problems already acquired and which may have a relationship with the noise to which they are subjected.

The Statistical Package for the Social Sciences (SPSS) software (IBM, 2017) and an electronic spreadsheet were used for statistical analysis of the data.

For the statistical tests, probability values (p) were used, with $p<0.05$ as dependency or weak significance, $p<0.01$ as dependency or moderate significance and $p\leq0.0001$ as dependency or strong significance.

Because it was categorical data, and because of the need to know the relationship between questions with different numbers of response options, Test G was used, an alternative to Pearson's Chi-square test (GOTELLI; ELLISON, 2016).

It was also used the ANOVA analysis of variance, which is the Fischer technique for partitioning the sum of the squares. This statistical technique aims to compare the variance of the results between the surveyed groups, which means that it checks if the answers of a group tend to be equal among themselves and different among the groups. However, it does not indicate which group presents differences (GOTELLI; ELLISON, 2016).

To identify the different groups, in the case of a significant Fischer test, the Bonferroni post-test was used. The Bonferroni test performs the analysis comparing the groups in two, allowing the identification of different groups (GOTELLI; ELLISON, 2016).

The ANOVA test and the Bonferroni test were used in the questions on the effects of noise on human health, in relation to the time the professional works in the current function.

The groups were categorized by time in the current function into five categories, from 0 to 5 years, from 6 to 10 years, from 11 to 15 years, from 16 to 20 years and from 21 to 25 years. The questions analyzed in this test were: "Do you notice that noise has harmed your health?", "Do you feel annoyed frequently?", "Do you have headaches frequently?", "Do you have insomnia frequently?", "Do you have trouble concentrating?", "Do you have digestion problems frequently?", "After working hours do you hear poorly, but then your hearing recovers normality?", "After working hours do you hear tinnitus, but then your hearing recovers normality?"

Outcomes and Discussion

Among the interviewees, 98.1% are male. Most work in the area of aircraft maintenance (68.8%), followed by administrative professionals (16.3%) and maintenance inspectors (11.5%). The two areas with the lowest number of respondents are maintenance manager and aircraft pilot, which represent 2.4% and 1.4% of respondents, respectively. These results can be seen in Table 1.

Table 1: Characterization of the population interviewed

General characteristics		n	%
Age	22 to 26 years	32	15,4
	27 to 31 years	78	37,5
	23 to 36 years	35	16,8
	37 to 41 years	33	15,8
	42 to 46 years	14	6,7
	47 to 52 years	16	7,7
ender	Male	204	98,1
	Female	04	1,9
Functio	Maintenance	143	68,7
	Inspector	24	11,5
	Manager	05	2,4
	Pilot	03	1,4
n	Administrative	34	16,3
Time (years) in current function	1 to 5 years	125	60,1
	6 to 10 years	60	28,8
	11 to 15 years	18	8,65
	16 to 20 years	02	0,9
	> 20 years	03	1,4

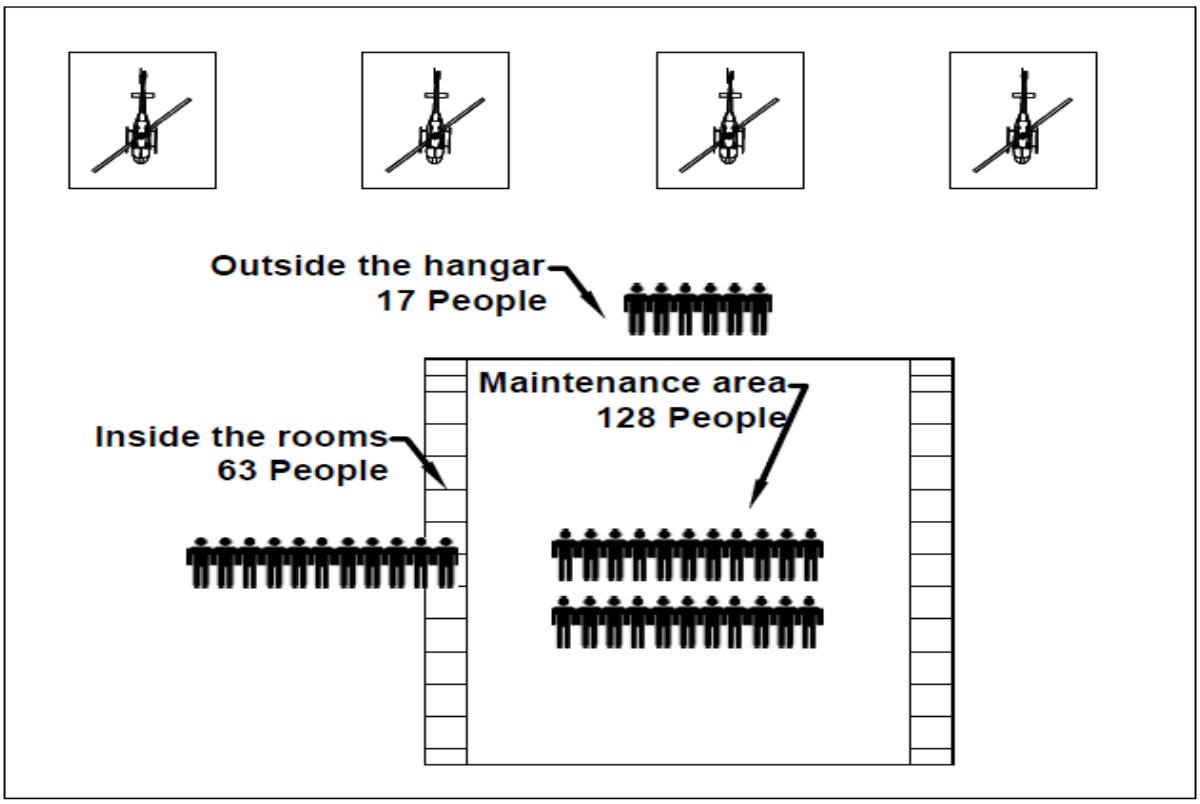
Source: research results.

The Cronbach alpha statistical test was performed to verify if the answers to the questionnaire were reliable. For the questionnaire to have a satisfactory index, the value found by the Cronbach alpha must be between 0.70 and 0.90 (ALMEIDA; SANTOS; COSTA, 2010). As a result, the value of 0.74 was reached, thus denoting a satisfactory index and demonstrating that the questionnaire adequately measures the proposed construct (ALMEIDA; SANTOS; COSTA, 2010).

Figure 1 shows the spatial distribution in the hangar of professionals who work four hours or more daily. The results show that the vast majority of professionals spend between two and six hours in the maintenance area and outside the hangar. Another 37 people reported staying two to four

hours daily outside the hangar and 17 people reported staying more than four hours daily. The professionals who stay the longest in and out of the hangar are the maintenance professionals.

Figure 1: Distribution of professionals in the workplace



Source: research results

Table 2 shows the frequency of affirmative answers to the questions according to the workplace in which the professional stays during his/her routine for more than four hours daily. The values are expressed by the number of affirmative answers and the percentage in relation to the group of professionals in each workplace.

As for the question "Did you notice that noise impaired your health?" the answer was 60.3% to 70.6% affirmative in all three locations, demonstrating that in all places professionals notice that noise impaired their health.

Regarding the question "Do you feel irritated frequently?" the answers indicated that professionals working in the maintenance area and outside the hangar are the ones who feel most irritated. The answer varied from 61.7% to 70.6% respectively and was 47.6% for those working inside the rooms. For the question "Do you have headaches frequently?" 52.9% of the professionals who work outside the hangar and 42.2% who work in the maintenance area answered yes. For those who work inside the rooms 28.6% answered yes.

For the question "Do you experience insomnia frequently?" the prevalence of positive reports was among professionals working in the maintenance area and outside the hangar. Regarding the question "Do you have trouble concentrating?" the prevalence was among the group of professionals working outside the hangar with 58.8% of positive answers. In the maintenance area and inside the rooms, the percentage of positive answers was 40.6% and 28.6% respectively.

As for the question "Do you often have problems with digestion?" there was a prevalence among professionals who work outside the hangar, with 41.2% of affirmative answers in this group. For the question "Do you hear poorly after working hours, but then hearing returns to normal?" the variation between the groups was from 22.2% to 31.3%, which means that there was not much variation. The same occurs for the question "After working hours you hear some tinnitus, but then hearing returns to normal?" whose variation was 17.5% to 30.5% between the three workplaces.

From Table 2 it was possible to verify that the highest incidence of symptoms and discomfort reported due to the workplaces were of the professionals who perform their functions outside the hangar and in the aircraft maintenance area.

Table 2: Frequency of responses depending on the workplace.

	Outside the hangar		Maintenance area		Inside the rooms	
	n	%	n	%	n	%
Did you notice that the noise damaged your health?	12	70,6%	89	69,5%	38	60,3%
Do you feel irritated frequently?	12	70,6%	79	61,7%	30	47,6%
Do you get headaches frequently?	09	52,9%	54	42,2%	18	28,6%
Do you experience insomnia frequently?	05	29,4%	39	30,5%	11	17,5%
Do you have trouble concentrating?	10	58,8%	52	40,6%	18	28,6%
Do you often have problems with digestion?	07	41,2%	24	18,8%	08	12,7%
After working hours do you hear poorly, but then your hearing returns to normal?	05	29,4%	40	31,3%	14	22,2%
After working hours you hear some tinnitus, but then your hearing returns to normal?	05	29,4%	39	30,5%	11	17,5%

Source: research results

Table 3 presents the health problems reported by respondents. It shows that 66.8% of the sample reported that their health was impaired by exposure to aircraft noise; 58.7% felt irritated frequently, and approximately 38.4% had difficulty concentrating. Of the total respondents, 134 said they perceived that noise impaired their health, 118 also said they often felt irritated, 78 said they had difficulty concentrating, 83 said they often had insomnia, and 52 reported hearing tinnitus after working hours.

Among the results found in Table 3, irritation, headaches, insomnia and difficulty in concentration may cause the individual to develop fatigue and loss of attention, resulting in errors in their activities (KJELLBERG; MUHR; SKOLDSTROM, 1998, TELES; MEDEIROS, 2007, WEBER; PÉRICO, 2011, ANJOS, 2012; HALPERIN, 2014, BODIN *et al.*, 2015, BISTAFA, 2018, CARTHEY, 2019, SILVA, 2020).

Table 3: Answers to reported health problems.

	Yes	
	n	%
Did you notice that the noise damaged your health?	139	66,8
Do you feel irritated often?	121	58,7
Do you experience headaches frequently?	81	38,9
Do you experience insomnia frequently?	55	26,4
Do you have trouble concentrating?	80	38,4
Do you often have digestion-related problems?	39	18,7
After working hours, does your hearing return to normal?	59	28,3
After working hours you hear some tinnitus, but then your hearing returns to normal?	55	26,4
Do you have a blood pressure problem?	9	4,3
Do you have a hearing problem?	44	21,1

Source: research results

Table 4 presents the results of the questions related to the perception of the interviewees regarding sound exposure demonstrated by the number of professionals who gave positive answers to the questions. A weak correlation was identified in the responses to the damage "causing headaches" and "causing cardiovascular problems", with a value of p= 0.01 (weak dependence) and p=0.004 (moderate dependence). This means that, according to the function performed, not all respondents fully agree that noise pollution can cause headaches and cardiovascular problems.

For the questions "Can exposure to noise be harmful to health?", "Is noise a risk factor in your workplace?", "Can noise cause a reduction in hearing ability?", "Can noise cause irritation?", "Can noise cause loss of concentration?" and "Can noise cause loss of sleep?" was found p>0.05, i.e. the answers were generally homogeneous. The majority (ranging from 88.9% to 99.0%) answered in the affirmative, demonstrating that professionals are aware that excessive noise can compromise their health and bring them undesirable effects.

Table 4: Perception of interviewees regarding sound exposure.

	Yes	
	n	%
Can exposure to noise be harmful to health?	206	99,0
Is noise a risk factor in your workplace?	201	96,6
Can noise cause a reduction in hearing ability?	206	99,0
Can noise cause irritation?	204	98,1
Can noise cause headaches?	199	95,7
Can noise cause sleep loss?	185	88,9
Can noise cause loss of concentration?	198	95,2
Can noise cause cardiovascular problems?	149	71,6

Source: research results

Being aware that noise pollution can be harmful to health causes the professional to take mitigating measures regarding their exposure. The study by Heyer *et al.* (2011) shows that the lack of knowledge of health risks from noise exposure leads to a lack of protection, increasing the possibilities of health damage.

An analysis of the answers of the interviewees regarding the annoyance and damage caused to their health in relation to the time of the professional in the current position was carried out. We identified weak dependence in the answers, comparing the age of the interviewees in two questions: as to noise causing headaches (p = 0.046) and causing concentration difficulties (p = 0.045); and strong dependence was identified in the question as to hearing problems (p = 0.0001). Therefore, there were significant differences between the ages of the groups who responded by having headaches frequently, having concentration difficulties and hearing problems, and those who responded by not having any of these symptoms.

Insomnia, difficulties in concentrating and auditory tinnitus after working hours are inducers that can result in mental stress and fatigue (CELESTINO, 2017). Halperin (2014) and Bodin *et al.* (2015) show that sleep disorders prevent adequate rest and generate physical and mental fatigue, cause irritation and reduce concentration and decision-making skills. Kjellberg, Muhr and Skoldstrom (1998) found an association between headache and fatigue after exposure to noisy environments. Bistafa (2018), Anjos (2013) and Teles and Medeiros (2007) associated the exposure of individuals to high levels of noise with digestive problems. Atalay, Babakurban and Aydin (2015) and Boger and Barreto (2015) claim that noise exposure can lead to hearing problems such as loss or reduced hearing ability and permanent tinnitus.

With the exception of blood pressure problems, all other health-related problems had a significant number of positive responses. These symptoms or health problems may be related to exposure to aircraft noise.

The results of the ANOVA statistical test identified significant differences between the answers of the surveyed groups, mainly in relation to the age group from 0 to 5 years in the current position, meaning the professionals who have been for less time in the current position. However, due to the high job rotation of professionals and the change of workplace, the groups with more time in the current position were small. Thus, the results found were not significant.

Table 5 shows the results of the interviewees who reported blood pressure and hearing problems. It can be seen that only 4.3% (n= 9) and p< 0.0001 reported blood pressure problems and 21.6% (n= 45) and p< 0.0001 reported hearing problems.

Table 5 - Blood pressure and hearing problems and the time they occur

Blood Pressure Problem	Time (years) presenting problems					Test
	n	≤ 2	2 a 4	4 a 6	> 6	Total	
Yes	00	3	0	0	0	09	p<0,00
No	19 8	0	2 1	2 0	2 0	01 199	
Hearing Problem							
Yes	01	9	1 7	0 5	0 3	45	p<0,00
No	16 2	0	0 0	0 0	0 1	01 163	

Source: research results

In the analysis of the relationship between hearing problems and the age of respondents, the result showed that the difference (G test = 42.3; p < 0.0001) between those who claimed to have hearing problems and those who did not was significant. Based on this premise, an analysis of professionals with hearing problems was carried out according to age and time working in the aeronautical sector.

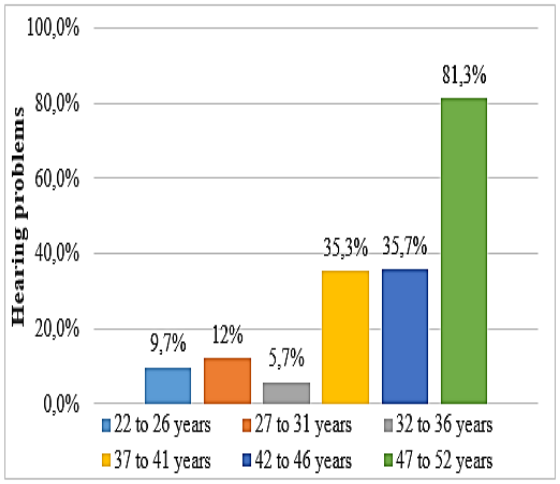
Figure 2 shows the number of hearing loss cases according to the age of the interviewees and the percentage for each age group. It is important to note that the number of interviewees who answered that they did not have any hearing problem is mostly among the first three age groups, being 22 to 26 years, 27 to 31 years, and 32 to 37 years.

From the age group of 37 to 41 years, the incidence of people who claimed to have hearing problems increased significantly. Between the ages of 42 and 46 and 47 and 52, the majority declared hearing impairment. This result shows a reversal in the frequency distribution, since 81.3 % of the 47 to 52 age group declared having hearing problems, and only 9.7 % of the 22 to 26 age group declared having some hearing problem.

The time that the professional works in aviation-related activities is another point to be discussed. The professionals with the most hearing problems are those who are older and have been working for the longest time, showing that the more advanced the professional's age and the longer the working time in the air activity, the greater are the chances of problems due to long periods of exposure.

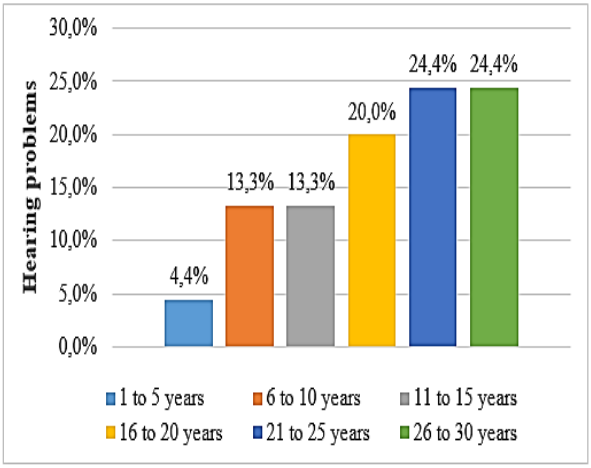
In Figure 3, it can be seen that the participants with the longest working time in aviation were those with the most hearing problems. An increase in the number of those who reported hearing problems from 16 to 20 years of age (20.0%), where, in the 21 to 25 and 26 to 30 age groups, it was 24.4%.

Figure 1: Age-related hearing problems.



Source: research results

Figure 2: Hearing problems due to time working in the aeronautical sector.



Source: research results

The results of Figure 2 and Figure 3 corroborate Atalay, Babakurban and Aydin (2015), who identified that the older the professional and the longer the time he develops activities related to the aeronautical sector, the greater are the chances of developing hearing problems. Hearing problems interfere negatively with communication and are factors that can compromise safety and professional performance in the work environment.

Final considerations

The objective of this work was to evaluate the impact of noise pressure level on the physical and mental performance of professionals at an aeronautical maintenance facility. A self-report questionnaire was applied to the professionals and the results suggest that noise is a contributing factor to the reduction of productivity in daily activities due to the physical and mental effects generated.

Many interviewees reported frequent irritation, difficulties in concentrating, frequent headaches and hearing loss after working hours and later normalization, tinnitus after working hours, frequent insomnia and hearing problems.

There was hearing loss reported by professionals, from 37 years of age and 16 years of service in aviation. Hearing loss and/or disability can have a negative impact on the work environment, since it interferes with communication, task transmissions and teamwork activities increasing the chances of mistakes in activities.

Most of the interviewees were aware that exposure to high noise levels can compromise their health. This result can be considered positive, as knowledge of the negative health effects of noise exposure leads the individual to look for ways to mitigate this exposure in their work environment.

Thus, it is concluded that the noise pressure level generated in the evaluated aeronautical maintenance facility are factors that, associated with other variables, can compromise the quality and safety of operations in the working environment.

References

ALMEIDA, D.; SANTOS, M. A. R.; COSTA, A. F. B. Aplicação do coeficiente alfa de Cronbach nos resultados de um questionário para avaliação de desempenho da saúde pública. *In*: XXX ENCONTRO NACIONAL DE ENGENHARIA DE PRODUÇÃO. **Anais...** São Carlos: Enegep, 2010.

ANJOS, T. F. A. **Dosimetria de ruído: comparação dos resultados gerados a partir de diferentes períodos de medição.** 2013. 63 f. Monografia (Especialização) - Curso de Engenharia de Segurança do Trabalho, Universidade Tecnológica Federal do Paraná, Curitiba, 2012.

ATALAY, H.; BABAKURBAN, S. T.; AYDIN, E. Evaluation of hearing loss in pilots. **Turkish Archives of Otorhinolaryngology**, v. 53, n. 4, p. 155, 2015.

BABISCH, W.; KAMP, I. V. Exposure-response relationship of the association between aircraft noise and the risk of hypertension. **Noise and Health**, v. 11, n. 44, p. 161, 2009.

BARBOSA, A. L. S. **Estudo de barreiras acústicas para a atenuação do ruído aeronáutico no Aeroporto de Congonhas em São Paulo.** 2015. Tese (Doutorado em Arquitetura e Urbanismo) - Universidade de São Paulo, São Paulo, 2015.

BELOJEVIC, G. A., JAKOVLJEVIC, B. D., STOJANOV, V. J., SLEPCEVIC, V. Z., PAUNOVIC, K. Z. Nighttime Road-Traffic Noise and Arterial Hypertension in an Urban Population**. Hypertension Research,** v. 31, n. 4, p. 775 – 781. 2008

BISTAFA, S. R. **Acústica Aplicada ao Controle de Ruído.** 3. ed. São Paulo: Edgard Blücher Ltda, 2018.

BODIN, T.; BJÖRK, J.; ARDÖ, J.; ALBIN, M. Annoyance, sleep and concentration problems due to combined traffic noise and the benefit of quiet side. **International Journal of Environmental Research and Public Health**, v. 12, n. 2, p. 1612 - 1628, 2015.

BOGER, M. E.; BARRETO, M. A. S. C. Zumbido e perda auditiva induzida por ruído em trabalhadores expostos ao ruído ocupacional. **Gestão e Saúde**, v. 6, n. 2, p. 1321- 1333. 2015.

BRITO, L. A. P. F.; BARBOSA, A. S. Incremento do Nível de Ruído no Meio Urbano Devido às Atividades Turísticas: Estudo de Caso na Cidade de Campos do Jordão. **Revista Tecno-Lógica**, v.18, n. 2, p. 84 - 89. 2014.

BRITO, L. A. P. F. de. A eficiência de algoritmos matemáticos para avaliação do ruído urbano. **Revista Brasileira de Gestão Urbana**, v. 10, n. 1, p. 22-35, 2018.

CAMPOS, D. P. A. **Capacitação de uma empresa aeronáutica para manutenção de alguns componentes de aeronaves**. 2015. Dissertação (Mestrado em Engenharia Mecânica) - Universidade Nova de Lisboa, Lisboa, 2015.

CARTHEY, J. Creating Safety II in the operating theatre: The Durable Dozen! **Journal of Perioperative Practice**, v. 29, n. 7 - 8, p. 210 - 215, 2019.

CELESTINO, V. R. R. **Fadiga no trabalho de pilotos: uma psicologia sistêmica da aviação civil**. Tese (Doutorado em psicologia) - Universidade Católica de Brasília, Brasília, 2017.

DIAS, A.; CORDEIRO, R.; GONÇALVES, C. G. O. Exposição ocupacional ao ruído e acidentes do trabalho. **Cadernos de Saúde Pública**, v. 22, p. 2125-2130, 2006.

FRONE, Michael R.; BLAIS, Ann-Renee. Work Fatigue in a Non-Deployed Military Setting: Assessment, Prevalence, Predictors, and Outcomes. **International Journal of Environmental Research and Public Health,** v. 16, n. 16, p. 2892, 2019.

GOTELLI, Nicholas J.; ELLISON, Aaron M. **Princípios de Estatística em Ecologia**. São Paulo: Artmed, 2016.

GOUVEIA, V. V.; OLIVEIRA, G. F.; MENDES, L. A. C.; SOUZA, L. E. C.; CAVALCANTI, T. M.; MELO, R. L. P. Escala de avaliação da fadiga: adaptação para profissionais da saúde. **Revista Psicologia, Organizações e Trabalho**, v. 15, n. 3, p. 246-256. 2015.

HALPERIN, D. Environmental noise and sleep disturbances: A threat to health? **Sleep Science**, v. 7, n. 4, p. 209 - 212, 2014.

HEYER, N.; MORATA, T. C.; PINKERTON, L. E.; BRUECK, S. E.; STANCESCU, D.; PANACCIO, M. P.; KIM, H.; SINCLAIR, J. S.; WATERS, M. A.; ESTILL, C. F.; FRANKS, J. Use of historical data and a novel metric in the evaluation of the effectiveness of hearing conservation program components. **Occupational and Environmental Medicine**, v. 68, n. 7, p. 510-517, 2011.

IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corporation.

KANASHIRO, Ricardo Gakiya. Jornada de voo na aviação de transporte e a prevenção da fadiga. **Revista Conexão SIPAER**, v. 4, n. 2, p. 190 - 199, 2013.

KJELLBERG, A.; MUHR, P.; SKOLDSTROM, B. Fatigue after work in noise - an epidemiological survey study and three quasi-experimental field studies. **Noise and Health**, v. 1, n. 1, p. 47, 1998.

KUBE, L. C. Fisiologia da fadiga, suas implicações na saúde do aviador e na segurança na aviação. **Revista Conexão SIPAER**, v. 2, n. 1, p. 35 - 57, 2010.

LEE, S.; KATSURA, T.; SHIMOMURA, Y.; LIU, X. X.; KONNO. F.; ONISHI, M.; TADA, M.; KOTEGAWA, K. Effects of Active Noise Control on Physiological Functions. **Journal of the Human-Environment System**, v. 12, n. 2, p. 49 – 54. 2009

PALMA, M. I. **O mapa de ruído como instrumento de planejamento: o caso da poluição sonora causada pelos automóveis no município de São Paulo**. 2018. Dissertação (Mestrado em Saúde Pública). Universidade de São Paulo, São Paulo, 2018.

PÁSCOA, S. F, **Impacto do ruído no desempenho cognitivo.** 2015. 109 f. Dissertação (Mestrado em Engenharia de Segurança e Higiene Ocupacional) - Universidade do Porto, Porto, 2015.

PIRRERA, S., VALCK, E., CLUYDTS, R. Field study on the impact of nocturnal road traffic noise on sleep: The importance of in- and outdoor noise assessment, the bedroom location and nighttime noise disturbances. **Science of the Total Environment**, v. 500, p. 84 – 90. 2014.

SILVA, R. F. G. **Gestão do ruído aeronáutico no aeródromo do Comando de Aviação do Exército**. 2020. Dissertação (Mestrado em Gestão e Desenvolvimento Regional) - Universidade de Taubaté, Taubaté, 2020.

SILVA, J. P. R.; SILVA, R. F. G.; BRITO, L. A. P. F. Paisagem Sonora: análise da paisagem sonora do aeródromo do Comando de Aviação do Exército brasileiro. *In*: SIMPÓSIO DE ACÚSTICA E VIBRAÇÕES ITECONS, 2, 2019, Coimbra. **Anais ... Itecons,** Coimbra: Uc, 2019. p. 1 - 5.

SILVA, R. F. G., BRITO, L. A. P. F, VIEIRA, E. T. Crescimento econômico e desenvolvimento econômico: uma análise pelo índice FIRJAN e PIB *per capita* do município de São José dos Campos–SP. **Gestão e Desenvolvimento em Revista**, v.5, n. 2, p. 59-68. 2019.

SKALEE, J. W., BRANDÃO, E.; TEIXEIRA, R. C. Estudo preliminar sobre a avaliação do ruído e aplicação do método científico na escolha de protetores auditivos para uso em ambientes industriais. **Revista Espacios,** v. 35, n. 10. 2014.

SONEGO, M. T.; SANTOS FILHA, V. A. V.; MORAES, A. B. Equipamento de proteção individual auricular: avaliação da efetividade em trabalhadores expostos a ruído. **Revista CEFAC**, v. 18, n. 3, p. 667-676. 2016.

TELES, R. M.; MEDEIROS, M. P. H. Perfil audiométrico de trabalhadores do distrito industrial de Maracanaú CE. **Revista da Sociedade Brasileira de Fonoaudiologia**, v. 12, n. 3, p. 233 – 239. 2007.

VIANA, L. S.; TEIXEIRA, K. M. D. Implicações da Perda Auditiva e do Zumbido na Qualidade de Vida no Trabalho de Servidores Expostos ao Ruído. **Sociedade em Debate**, v. 23, n. 2, p. 331 - 357, 2017.

VIANNA, K. M. P. **Poluição sonora no município de São Paulo: avaliação do ruído e o impacto da exposição na saúde da população**. 2014. Tese (Doutorado em Saúde Pública) - Universidade de São Paulo, São Paulo, 2014.

VIEIRA, S. **Introdução à bioestatística**. 4. ed. Rio de Janeiro: Elsevier, 2011.

WEBER, N., HAASE, D., FRANCK, U. Assessing modeled outdoor traffic-induced noise and air pollution around urban structures using the concept of landscape metrics. **Landscape and Urban Planning**, v. 125, p. 105 – 116. 2014.

WEBER, S. R.; PÉRICO, E. Zumbido no trabalhador exposto ao ruído. **Revista da Sociedade Brasileira de Fonoaudiologia**, v. 16, n. 4, 2011.

WORLD HEALTH ORGANIZATION (WHO). Night noise guidelines for Europe. Copenhagen: WHO Regional Office 2009.

WORLD HEALTH ORGANIZATION (WHO). Guidelines for Community Noise. London: WHO, Regional Office 1999.